

LLWMA-2 is located in the 200 East Area and includes all of the 218-E-12B Burial Ground. Upgradient well 299-E34-7 exceeded the critical mean value for specific conductance in 2000. Sulfate and calcium are the major contributors to the increase and their source is not known. However, only 0.6 m (2 ft) of water remains in this well, which is at the top of the basalt, and the increases may be due to basalt chemistry. Well 299-E34-7 also exceeded the comparison value for total organic carbon in 2000. Results for volatile and semi-volatile organics were less than detection limits, with the exception of bis (2-ethylhexyl) phthalate at 1.7 µg/L.

LLWMA-3 includes the 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds in the 200 West Area. Indicator parameter data from upgradient wells were statistically evaluated and values from downgradient wells were compared with established values from upgradient wells in 2000. The critical mean value for specific conductance was exceeded in an upgradient well, but is due to increases in sulfate and nitrate from upgradient sources. None of the other wells in LLWMA-3 exceeded contamination parameters during 2000. Several of the wells in LLWMA-3 have gone dry, as the water table continues to decline.

LLWMA-4 is located in the 200 West Area and includes 218-W-4B and 218-W 4C Burial Grounds. Indicator parameter data from upgradient wells were statistically evaluated and values from downgradient wells were compared with established values from upgradient wells in 2000. The critical mean value for total organic halides was exceeded in one downgradient well in 2000, caused by carbon tetrachloride from an upgradient source. Groundwater in LLWMA-4 is being actively remediated using pump-and-treat methods.

DOE has an Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project (Hartman et al. 2002a) that integrates all of the separate monitoring plans that are prepared for RCRA, CERCLA, and DOE Orders. Groundwater is a dynamic system, and the monitoring network is annually reviewed and modified to accommodate changes. Any additional wells for the LLBGs will be defined through the RCRA permit process and will be drilled under the TPA M-24 Milestone. DOE-RL has worked with EPA and Ecology to revise the M-24 Milestone as needed, and tentative agreement has been reached on a four-year schedule for drilling additional wells, including 17 proposed new wells for the LLBG waste management areas. The M-24 TPA Change Package for the new wells was issued for public comment in September 2003. A total of 1,278 wells are scheduled to be sampled in fiscal years 2003, 2004, or 2005 for all programs combined.

## **4.6 Biological and Ecological Resources**

The Hanford Site is characterized as a shrub-steppe ecosystem (Daubenmire 1970). Such ecosystems are typically dominated by a shrub overstory with a grass understory. In the early 1800s, the dominant plant in the area was big sagebrush underlain by perennial Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement, livestock grazing and agricultural production contributed to colonization by nonnative vegetation species that currently dominate the landscape. Although agriculture and production of livestock were the primary activities at the beginning of the twentieth century, these activities ceased when the site was established in 1943. Remnants of past agricultural practices are still evident.

The Columbia River borders the DOE-managed portion of the Hanford Site to the east. Operation of Priest Rapids Dam upstream of the site accommodates maintenance of intakes at the Hanford Site and helps to manage anadromous fish populations. The Columbia River and associated riparian zones provide habitat for numerous wildlife and vegetation species.

Large areas of the Hanford Site have experienced range fires that have greatly influenced the vegetation canopy and distribution of wildlife. In 1984, a major fire burned across 800 km<sup>2</sup> (310 mi<sup>2</sup>) of the Hanford Site (Price et al. 1986). From June 27 through July 2, 2000, the *24 Command Fire* burned across the Hanford Site consuming most of the shrub-steppe habitat on the ALE Unit, a small section of the McGee-Riverlands Unit, and other southwestern portions of the site. The fire consumed a total of 655 km<sup>2</sup> (250 mi<sup>2</sup>) of federal, state, and private lands before it was controlled (BAER 2000). Range fires are a component of natural plant succession.

The Hanford Site Fire Department provides the planning to guide the management of wildland and prescribed fires on the site. This planning is designed to ensure safety, protect facilities and resources, and restore and perpetuate natural processes.

DOE manages the Hanford Site through the Hanford Site Biological Resources Management Plan (BRMaP; DOE-RL 2001) and the Hanford Site Biological Resources Mitigation Strategy (BRMiS; DOE-RL 2003b) that were adopted after preparation of the HCP EIS (DOE 1999), which included an ecosystem analysis.

#### **4.6.1 Vegetation**

Plants at the Hanford Site are adapted to low annual precipitation, low water-holding capacity of the rooting substrate (sand), dry summers, and cold winters. Range fires that burn through the area during dry summers have reduced species that are less resistant to fire (for example, big sagebrush) and have allowed more opportunistic and fire-resistant species a chance to become established. Perennial shrubs and bunchgrasses generally dominate native plant communities on the site. However, Euro-American settlement and development have resulted in the proliferation of non-native species. Of the 590 species of vascular plants recorded on the Hanford Site, approximately 20 percent of the species are considered nonnative (Sackschewsky et al. 1992). Cheatgrass is the dominant non-native species. It is an aggressive colonizer and has become well established across the site (Rickard and Rogers 1983). The biodiversity inventories conducted by The Nature Conservancy of Washington (TNC 1999) have identified 85 additional taxa, establishing the actual number of plant taxa on the Hanford Site at 675.

The Nature Conservancy of Washington also conducted rare plant surveys. The Conservancy found 112 populations/occurrences of 28 rare plant taxa on the Hanford Site. When combined with observations preceding the 1994-1999 inventories, a total of 127 populations of 30 rare plant taxa have been documented on the Hanford Site (TNC 1999).

Figure 4.21 shows existing vegetation and land use areas on the Hanford Site, prior to the *24 Command Fire* that occurred in late June 2000. Table 4.11 presents a list of common plant species in shrub-steppe and riparian areas.

**Table 4.11.** Common Vascular Plants on the Hanford Site  
(Taxonomy follows Hitchcock and Cronquist 1973)

<b>A. Shrub-Steppe Species</b>	<b>Scientific Name</b>
<b>Shrub</b>	
big sagebrush	<i>Artemisia tridentata</i>
bitterbrush	<i>Purshia tridentata</i>
gray rabbitbrush	<i>Chrysothamnus nauseosus</i>
green rabbitbrush	<i>Chrysothamnus viscidiflorus</i>
snow buckwheat	<i>Eriogonum niveum</i>
spiny hopsage	<i>Grayia (Atriplex) spinosa</i>
threetip sagebrush	<i>Artemisia tripartita</i>
<b>Perennial Grasses</b>	
bluebunch wheatgrass	<i>Agropyron spicatum</i>
bottlebrush squirreltail	<i>Sitanion hystrix</i>
crested wheatgrass	<i>Agropyron desertorum (cristatum)</i> <sup>(a)</sup>
indian ricegrass	<i>Oryzopsis hymenoides</i>
needle-and-thread grass	<i>Stipa comata</i>
prairie junegrass	<i>Koeleria cristata</i>
sand dropseed	<i>Sporobolus cryptandrus</i>
Sandberg's bluegrass	<i>Poa sandbergii (secunda)</i>
thickspike wheatgrass	<i>Agropyron dasytachyum</i>
<b>Perennial Forbs</b>	
bastard toad flax	<i>Comandra umbellata</i>
buckwheat milkvetch	<i>Astragalus caricinus</i>
Carey's balsamroot	<i>Balsamorhiza careyana</i>
Cusick's sunflower	<i>Helianthus cusickii</i>
cutleaf ladysfoot mustard	<i>Thelypodium laciniatum</i>
Douglas' clusterlily	<i>Brodiaea douglasii</i>
dune scurfpea	<i>Psoralea lanceolata</i>
Franklin's sandwort	<i>Arenaria franklinii</i>
Gray's desertparsley	<i>Lomatium grayi</i>
hoary aster	<i>Machaeranthera canescens</i>
hoary falseyarrow	<i>Chaenactis douglasii</i>
longleaf phlox	<i>Phlox longifolia</i>

**Table 4.11. (contd)**

<b>A. Shrub-Steppe Species</b>	<b>Scientific Name</b>
<b>Perennial Forbs (cont)</b>	
Munro's globemallow	<i>Sphaeralcea munroana</i>
pale evening primrose	<i>Oenothera pallida</i>
sand beardtongue	<i>Penstemon acuminatus</i>
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>
threadleaf fleabane	<i>Erigeron filifolius</i>
turpentine spring parsley	<i>Cymopterus terebinthinus</i>
winged dock	<i>Rumex venosus</i>
yarrow	<i>Achillea millefolium</i>
yellow bell	<i>Fritillaria pudica</i>
<b>Annual Forbs</b>	
annual Jacob's ladder	<i>Polemonium micranthum</i>
blue mustard	<i>Chorispora tenella</i> <sup>(a)</sup>
bur ragweed	<i>Ambrosia acanthicarpa</i>
clasping pepperweed	<i>Lepidium perfoliatum</i>
indian wheat	<i>Plantago patagonica</i>
jagged chickweed	<i>Holosteum umbellatum</i> <sup>(a)</sup>
Jim Hill's tumbledmustard	<i>Sisymbrium altissimum</i> <sup>(a)</sup>
matted cryptantha	<i>Cryptantha circumscissa</i>
pink microsteris	<i>Microsteris gracilis</i>
prickly lettuce	<i>Lactuca serriola</i> <sup>(a)</sup>
rough wallflower	<i>Erysimum asperum</i>
Russian thistle (tumbleweed)	<i>Salsola kali</i> <sup>(a)</sup>
slender hawksbeard	<i>Crepis atrabarba</i>
spring whitlowgrass	<i>Draba verna</i> <sup>(a)</sup>
storksbill	<i>Erodium cicutarium</i> <sup>(a)</sup>
tall willowherb	<i>Epilobium paniculatum</i>
tarweed fiddleneck	<i>Amsinckia lycopsoides</i>
threadleaf scorpion weed	<i>Phacelia linearis</i>

**Table 4.11. (contd)**

<b>A. Shrub-Steppe Species</b>	<b>Scientific Name</b>
<b>Annual Forbs (contd)</b>	
western tansymustard	<i>Descurainia pinnata</i>
white cupseed	<i>Plectritis macrocera</i>
whitestem stickleaf	<i>Mentzelia albicaulis</i>
winged cryptantha	<i>Cryptantha pterocarya</i>
yellow salsify	<i>Tragopogon dubius</i> <sup>(a)</sup>
<b>Annual Grasses</b>	
cheatgrass	<i>Bromus tectorum</i> <sup>(a)</sup>
slender sixweeks	<i>Festuca octoflora</i>
small sixweeks	<i>Festuca microstachys</i>
<b>Trees and Shrubs</b>	
black cottonwood	<i>Populus trichocarpa</i>
black locust	<i>Robinia pseudo-acacia</i>
coyote willow	<i>Salix exigua</i>
dogbane	<i>Apocynum cannabinum</i>
peach, apricot, cherry	<i>Prunus</i> spp.
peachleaf willow	<i>Salix amygdaloides</i>
willow	<i>Salix</i> spp.
white mulberry	<i>Morus alba</i> <sup>(a)</sup>
<b>B. Riparian Species</b>	<b>Scientific Name</b>
<b>Perennial Grasses and Forbs</b>	
bentgrass	<i>Agrostis</i> spp. <sup>(b)</sup>
blanket flower	<i>Gaillardia aristata</i>
bulrushes	<i>Scirpus</i> spp. <sup>(b)</sup>
cattail	<i>Typha latifolia</i> <sup>(b)</sup>
Columbia River gumweed	<i>Grindelia columbiana</i>
hairy golden aster	<i>Heterotheca villosa</i>
heartweed	<i>Polygonum persicaria</i>
horsetails	<i>Equisetum</i> spp.

**Table 4.11. (contd)**

<b>B. Riparian Species</b>	<b>Scientific Name</b>
Perennial Grasses and Forbs (contd)	
horseweed tickseed	<i>Coreopsis atkinsoniana</i>
lovegrass	<i>Eragrostis</i> spp. <sup>(b)</sup>
lupine	<i>Lupinus</i> spp.
meadow foxtail	<i>Alopecurus aequalis</i> <sup>(b)</sup>
Pacific sage	<i>Artemisia campestris</i>
prairie sagebrush	<i>Artemisia ludoviciana</i>
reed canary grass	<i>Phalaris arundinacea</i> <sup>(b)</sup>
rushes	<i>Juncus</i> spp.
Russian knapweed	<i>Centaurea repens</i> <sup>(a)</sup>
sedge	<i>Carex</i> spp. <sup>(b)</sup>
water speedwell	<i>Veronica anagallis-aquatica</i>
western goldenrod	<i>Solidago occidentalis</i>
wild onion	<i>Allium</i> spp.
wiregrass spikerush	<i>Eleocharis</i> spp. <sup>(b)</sup>
Aquatic Vascular	
Canadian waterweed	<i>Elodea Canadensis</i>
Columbia yellowcress	<i>Rorippa columbiae</i>
duckweed	<i>Lemna minor</i>
pondweed	<i>Potamogeton</i> spp.
spiked water milfoil	<i>Myriophyllum spicatum</i>
watercress	<i>Rorippa nasturtium-aquaticum</i>
(a) Introduced.	
(b) Perennial grasses and graminoids.	

**200 Areas Flora.** Waste management areas and crib sites are generally either barren or vegetated by invasive species, including Russian thistle (tumbleweed), tumble mustard, and cheatgrass. Russian thistle and gray rabbitbrush occurring in these areas are deep rooted and have the potential to accumulate radionuclides and other buried contaminants, functioning as a pathway to other parts of the ecosystem (Landeen et al. 1993). Russian thistle, an annual weed, accumulates nitrates and soluble oxalates, and has significant seed dispersion. Vegetation samples are collected annually from the 200/600 Areas and analyzed for uranium, cobalt-60, strontium-90, cesium-137, and plutonium-239/240. The Hanford Integrated Biological Control (IBC) program was established to control the growth of deep-rooted vegetation over contaminated and potentially contaminated waste sites. The program also established vegetation control through herbicide spraying and cleanup activities. The effectiveness of the program is directly related to the timeliness of herbicide application and removal of tumbleweeds, rabbitbrush, and sagebrush.

The portions of the 200 Areas undisturbed by DOE and its predecessor agencies, but previously disturbed by farmers and ranchers, are characterized as sagebrush/cheatgrass or Sandberg's bluegrass communities of the 200 Area Plateau. Cheatgrass provides half of the total plant cover. Most of the waste disposal and storage sites are covered by nonnative vegetation or are kept in a vegetation-free condition with the use of herbicides, because the plants could potentially accumulate waste constituents. Figures 4.22 and 4.23 illustrate existing vegetation and land use areas mapped prior to the *24 Command Fire* for the 200 West Area and 200 East Area, respectively. Early observations suggest the soil structure and seed bank may have been damaged to the point where vegetative recovery will be slower than in other areas, and the resulting community may not resemble the sagebrush-steppe that existed before the fire.

West Lake and its immediate basin represent a unique habitat that is characterized by highly saline conditions (Poston et al. 1991). Water levels of the pond fluctuate with groundwater levels. Predominant plants include salt grass, plantain, and rattlebox. Three-spine bulrush grows along the shoreline.

#### **4.6.2 Wildlife**

Three hundred species of terrestrial vertebrates have been observed on the Hanford Site. The species list includes approximately 42 species of mammals, 246 species of birds, 5 species of amphibians, and 12 species of reptiles (Soll and Soper 1996; Brandt et al. 1993).

The shrub and grassland habitat of the Hanford Site supports many groups of terrestrial wildlife. Species include large game animals like Rocky Mountain elk and mule deer; predators such as coyote, bobcat, and badger; and herbivores like deer mice, harvest mice, ground squirrels, voles, and black-tailed jackrabbits. The most abundant mammal on the Hanford Site is the Great Basin pocket mouse.

Mule deer rely on shoreline vegetation and bitterbrush shrubs for browse (Tiller et al. 1997). Elk, which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub species during the summer months. Elk first appeared on the Hanford Site in 1972 (Fitzner and Gray 1991), and have increased from approximately eight animals in 1975 to 900 in 1999. The Rattlesnake Hills elk herd that inhabits the Hanford Site primarily occupies ALE and private lands that adjoin the reserve to the north and west. Elk are occasionally seen on the 200 Area Plateau and have been sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on ALE in the winter and disperses during the summer months to higher elevations on ALE, private land to the west of ALE, and the U.S. Army Yakima Training Center. Approximately 300 elk have been relocated or removed by special hunts during 1999-2000. Elk relocation continued in 2002. The *24 Command Fire* in June 2000 destroyed nearly all the elk forage on ALE. The herd moved onto unburned private land west of the site, to unburned areas on central Hanford, and along the Columbia River near the 100-B/C and 100-K Areas. Post-fire surveys suggest very low mortality of adult elk as a result of the wildfire.

However, the wildfire occurred in the middle of calving season, which may have an impact on the number of calves and their survival to adulthood. A cougar sighting on ALE was reported during the elk relocation effort in March 2000.

Shrubland and grassland provide nesting and foraging habitat for many passerine bird species. Surveys conducted during 1993 (Cadwell 1994) reported the occurrence of western meadowlarks and horned larks more frequently in shrubland habitats than in other habitats on the site. TNC (1999) reported a total of 41 species that are considered dependent on steppe or shrub-steppe habitat. Long-billed curlews and vesper sparrows were also noted as commonly occurring species in shrubland habitat. Species that are dependent on undisturbed shrub habitat include sage sparrow, sage thrasher, and loggerhead shrike. The sage sparrow and loggerhead shrike tend to roost and nest in sagebrush or bitterbrush that occurs at lower elevations (DOE-RL 2001). Ground-nesting species that occur in grass-covered uplands include long-billed curlews, western meadowlark, and burrowing owls.

Common upland game bird species that occur in shrub and grassland habitat include chukar partridge, California quail, and Chinese ring-necked pheasant. Chukars are most numerous in the Rattlesnake Hills, Yakima Ridge, Umtanum Ridge, Saddle Mountains, and Gable Mountain areas of the Hanford Site. Less common species include western sage grouse, Hungarian partridge, and scaled quail. Western sage grouse were historically abundant on the Hanford Site. However, populations have declined since the early 1800s because of the conversion of sagebrush-steppe habitat. Surveys conducted by the Washington State Department of Fish and Wildlife (WDFW) and PNNL during late winter and early spring 1993, and biodiversity inventories conducted by The Nature Conservancy in 1997, did not observe western sage grouse in sagebrush-steppe habitat at ALE. However, sage grouse have been observed on ALE in 1999 and 2000 (Tiller 2000).

Among the raptor species that use shrubland and grassland habitats are American kestrel, red-tailed hawk, Swainson's hawk, and ferruginous hawks. Northern harriers, sharp-shinned hawks, rough-legged hawks, and golden eagles also occur in these habitats but are not sighted as frequently. In 1994, nesting by red-tailed, Swainson's, and ferruginous hawks included 41 nests located across the Hanford Site on high voltage transmission towers, trees, cliffs, and basalt outcrops. In recent years, the number of nesting ferruginous hawks on the Hanford Site has increased, in part as a result of their acceptance of steel power line towers in the open grass and shrubland habitats.

Many species of insects occur throughout all habitats on the Hanford Site. Butterflies, grasshoppers, and darkling beetles are among the most conspicuous of the approximately 1500 species of insects that have been identified from specimens collected on the Hanford Site (TNC 1999). The actual number of insect species occurring on the Hanford Site may reach as high as 15,500. A total of 1509 species-level identifications were completed in 1999 and 500 more are expected. Recent surveys performed by The Nature Conservancy included the collection of 40,000 specimens and have resulted in the identification of 43 new taxa and 142 new findings in the state of Washington (TMC 1999). The high diversity of insect species on the Hanford Site is believed to reflect the size, complexity, and quality of the shrub-steppe habitat.



The side-blotched lizard is the most abundant reptile species that occurs on the Hanford Site. Sagebrush lizards and short-horned lizards are reportedly found on the site, but occur infrequently. The most common snake species include gopher snake, yellow-bellied racer, and Pacific rattlesnake. The Great Basin spadefoot toad, Woodhouse's toad, Pacific tree frog, tiger salamander, and bullfrog are the only amphibians found on the site (TNC 1999; Brandt et al. 1993).

With the cessation of production activities at Hanford, the amount of water discharged to the ground in the 200 Area Plateau has substantially decreased. West Lake has shrunk and is presently a group of small isolated pools and mud flats. Avocets and sandpipers still use the site, but it does not support coots or other nesting waterfowl.

#### **4.6.3 Aquatic Ecology**

Two types of natural aquatic habitats are found on the Hanford Site: the Columbia River that flows along the northern and eastern edges of the site, and the small spring-streams and seeps located mainly on ALE in the Rattlesnake Hills.

The Columbia River is the dominant aquatic ecosystem on the Hanford Site and supports a large and diverse community of plankton, benthic invertebrates, fish, and other communities. It has a drainage area of about 680,000 km<sup>2</sup> (260,000 mi<sup>2</sup>), an estimated average annual discharge of 6600 m<sup>3</sup>/s (71,000 ft<sup>3</sup>/s), and a total length of about 2000 km (1240 mi) from its origin in British Columbia to its mouth at the Pacific Ocean. The Columbia has been dammed upstream and downstream of the Hanford Site, and the Hanford Reach flowing through the site is the last free-flowing, but regulated, section of the Columbia River in the United States above Bonneville Dam. Plankton populations in the Hanford Reach are influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids Reservoir, and by manipulation of water levels below by dam operations in upstream and downstream reservoirs. Phytoplankton and zooplankton populations provide food for herbivores such as immature insects that are then consumed by predaceous species. These phytoplankton and zooplankton are largely transient, flowing from one reservoir to another. There is generally insufficient time for characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach. No tributaries enter the Columbia River during its passage through the Hanford Site; however, there are several irrigation water return canals that discharge into the river along the Franklin County shoreline.

Gray and Dauble (1977) listed 43 species of fish in the Hanford Reach of the Columbia River. The brown bullhead, collected since 1977, brings the total number of fish species identified in the Hanford Reach to 44. Of these species, Chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Additionally, fall Chinook salmon and steelhead trout spawn in the Hanford Reach.

Small interrupted streams, such as Rattlesnake and Snively springs, contain diverse biotic communities and are extremely productive (Cushing and Wolf 1984). Dense blooms of watercress occur and aquatic insect production is high compared with mountain streams (Gaines 1987). The macrobenthic biota varies from stream to stream and is related to the proximity of colonizing insects and other factors. Rattlesnake Springs is of ecological importance because it provides a source of water to terrestrial

animals in an otherwise arid part of the site. Snively Springs, located farther west and at a higher elevation than Rattlesnake Springs, is a source of drinking water for terrestrial animals. The major rooted aquatic plant, which in places may cover the entire width of the stream, is watercress (*Rorippa nasturtium-aquaticum*). Isolated patches of bulrush (*Scirpus* sp.), spike rush (*Eleocharis* sp.), and cattail (*Typha latifolia*) occupy less than 5 percent of the streambed.

#### 4.6.4 Threatened and Endangered Species

The federal Endangered Species Act (16 USC 1531-1544) defines endangered species as plants and animals in danger of extinction within the foreseeable future throughout all or a significant portion of its range. Threatened species are those likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Candidate species are plants and animals with a status of concern, but more information is needed before they can be proposed for listing.

No plants or mammals on the federal list of threatened and endangered wildlife and plants (50 CFR 17) are known to occur on the Hanford Site. However, the bald eagle and two species of fish (steelhead and spring-run Chinook salmon), currently found on the federal list of threatened and endangered species, are present on the Hanford Site on a regular basis. Surveys of the 200 Areas (Sackschewsky 2002, 2003) and Area C (Sackschewsky 2003) revealed no federal or state threatened or endangered species (see Appendix I).

Federally listed threatened, endangered, candidate species (50 CFR 17), and species of concern ([http://www.wa.gov/wdfw/wlm/diversty/soc/adv\\_search.htm](http://www.wa.gov/wdfw/wlm/diversty/soc/adv_search.htm)) and threatened and endangered species listed by Washington State (Washington Natural Heritage Program 2002) identified on the Hanford Site are shown in Table 4.12. Several candidate species of plants and animals are under consideration for formal listing by the federal government and Washington State. The FWS annually reviews the status of candidate species for listing under the Endangered Species Act. The results of these reviews are posted on the FWS homepage <http://www.fws.gov>. Several federal plant and animal species of concern require further information before the FWS can decide whether the species should be considered for formal listing ([http://www.wa.gov/wdfw/wlm/diversty/soc/adv\\_search.htm](http://www.wa.gov/wdfw/wlm/diversty/soc/adv_search.htm)). Anadromous fish are reviewed and listed by the National Marine Fisheries Service (NMFS) (<http://www.nwr.noaa.gov>).

Washington State defines endangered species as wildlife species native to the state of Washington that are seriously threatened with extinction throughout all or a significant portion of their ranges within the state. Threatened species include wildlife species native to the state that are likely to become an endangered species within the foreseeable future throughout a significant portion of their ranges within the state (WAC 232-12-297). A State of Washington sensitive species is a wildlife species native to the state that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats. The common loon (*Gavia immer*) is the only Washington State sensitive animal species found on the Hanford Site. Table 4.13 lists the Washington State-designated candidate animal species that potentially are found on the Hanford Site and are under consideration for possible addition to the threatened or endangered list. A state candidate species is one that is being reviewed for possible listing as a state endangered, threatened, or sensitive species as specified in Washington Department of Fish and Wildlife Policy M-6001 (WDFW 1998).

**Table 4.12.** Federally Listed Threatened, Endangered, Candidate Species, and Species of Concern and Washington State-Listed Threatened and Endangered Species Occurring or Potentially Occurring on the Hanford Site (Fitzner and Gray 1991, Landeen et al. 1992, FWS 2003, and Neitzel 2002a)

Common Name	Scientific Name	Federal	State <sup>(a)</sup>
<b>Plants</b>			
Columbia milkvetch	<i>Astragalus columbianus</i>	SC <sup>(b)</sup>	T <sup>(c)</sup>
dwarf evening primrose	Camissonia (= Oenothera) pygmaea		T
Hoover's desert parsley	Lomatium tuberosum	SC	T
Loeflingia	Loeflingia squarrosa var. squarrosa		T
persistent sepal yellowcress	Rorippa columbiae	SC	T
Umtanum desert (wild) buckwheat	Eriogonum codium	C <sup>(d)</sup>	E <sup>(e)</sup>
White Bluffs bladderpod	Lesquerella tuplashensis	C	E
white eatonella	Eatonella nivea		T
Ute ladies'-tresses <sup>(g)</sup>	<i>Spiranthes diluvialis</i>	T	
<b>Fish</b>			
bull trout <sup>(g)</sup>	<i>Salvelinus confluentus</i>	T	
spring-run Chinook	Oncorhynchus tshawytscha	E	C
Upper Columbia steelhead	Oncorhynchus mykiss	E	C
Middle Columbia steelhead	<i>Oncorhynchus mykiss</i>	T	C
<b>Birds</b>			
American white pelican	Pelecanus erythrorhynchos		E
bald eagle <sup>(f)</sup>	Haliaeetus leucocephalus	T	T
ferruginous hawk	Buteo regalis	SC	T
greater sage grouse	<i>Centrocercus urophasianus phaios</i>	C	T
olive-sided flycatcher	<i>Contopus cooperi</i>	SC	
sandhill crane	Grus canadensis		E
willow flycatcher	<i>Empidonax trailii</i>	SC	
yellow-billed cuckoo <sup>(g)</sup>	<i>Coccyzus americanus</i>	C	
<b>Reptiles</b>			
Northern sagebrush lizard	<i>Sceloporous graciosus</i>	SC	
(a) <a href="http://www.wa.gov/wdfw/selectHabitat/PriorityHabitatsandSpeciesList/SpeciesofConcernList/EndangeredSpecies(WAC232-12-297)">http://www.wa.gov/wdfw/ select Habitat, Priority Habitats and Species List, Species of Concern List, Endangered Species (WAC 232-12-297)</a> (b) SC = Federal species of concern, 50 CFR 17 <a href="http://www.fws.gov">http://www.fws.gov</a> . (c) T = Federal threatened species, 50 CFR 17 <a href="http://www.fws.gov">http://www.fws.gov</a> . (d) C = Federal candidate species, 50 CFR 17 <a href="http://www.fws.gov">http://www.fws.gov</a> . (e) E = Federal endangered species, 50 CFR 17 <a href="http://www.fws.gov">http://www.fws.gov</a> . (f) Currently under review for change in status. (g) Not believed present on the Hanford Site, but identified by FWS 2003.			

**Table 4.13.** Washington State Candidate Animal Species Found on the Hanford Site (Fitzner and Gray 1991; Landeen et al. 1992; and Neitzel 2002a)

Common Name	Scientific Name
<b>Molluscs</b>	
giant Columbia River spire snail <sup>(a,b)</sup>	<i>Fluminicola (= Lithoglyphus) columbiana</i>
giant Columbia River limpet	<i>Fisherola (= Lanx) nuttalli</i>
<b>Fish</b>	
spring-run Chinook <sup>(c)</sup>	<i>Oncorhynchus tshawytscha</i>
steelhead <sup>(b)</sup>	<i>Oncorhynchus mykiss</i>
<b>Insects</b>	
Columbia River tiger beetle <sup>(d)</sup>	<i>Cicindela columbica</i>
<b>Birds</b>	
burrowing owl <sup>(a,b)</sup>	<i>Athene cunicularia</i>
golden eagle	<i>Aquila chrysaetos</i>
Lewis' woodpecker	<i>Melanerpes lewis</i>
loggerhead shrike <sup>(a,b)</sup>	<i>Lanius ludovicianus</i>
merlin	<i>Falco columbarius</i>
northern goshawk <sup>(a,b,c)</sup>	<i>Accipiter gentilis</i>
sage sparrow	<i>Amphispiza belli</i>
sage thrasher	<i>Preoscotes montanus</i>
Vaux's swift	<i>Chaetura vauxi</i>
<b>Reptiles</b>	
striped whipsnake	<i>Masticophis taeniatus</i>
<b>Mammals</b>	
black-tailed jackrabbit	<i>Lepus californicus</i>
Merriam's shrew	<i>Sorex merriami</i>
Washington ground squirrel <sup>(f)</sup>	<i>Spermophilus washingtoni</i>
white-tailed jackrabbit	<i>Lepus townsendi</i>
(a) Information from Washington Department of Fish and Wildlife <a href="http://www.wa.gov/wdfw/">http://www.wa.gov/wdfw/</a> select Habitat, Priority Habitats and Species List, Species of Concern List (WDFW Policy M-6001 1988).	
(b) Federal endangered.	
(c) Probable, but not observed on the Hanford Site.	
(d) Reported, but seldom observed on the Hanford Site.	
(e) Federal candidate.	

Washington State considers shrub-steppe habitat as a priority habitat because of its relative scarcity in the state and because of its requirement as nesting/breeding habitat by several state and federal species of concern (see Figure 4.21 for vegetation habitat coverage). Designation and characterization of priority habitat serves to provide a basis for sound and defensible land management planning and assists the DOE in implementing sound stewardship activities into site management to protect regulated species.

Table 4.14 lists Washington State plant species of concern that are currently listed as sensitive or are in one of three monitored groups (Washington Natural Heritage Program 2002; TNC 1999). The

Washington Natural Heritage Program established the ratings reported in Table 4.14 as Sensitive (vulnerable or declining and could become endangered or threatened), Review 1 (more field work needed), and Review 2 (unresolved taxonomic problems).

Figure 4.24 shows the general locations of species of concern on the Hanford Site prior to the wildfire, and the 24 Command Fire coverage. In some areas the wildfire burn intensity was generally low, allowing belowground portions of some perennial plants and seeds to survive. However, there were some areas of high burn where the soil and seed bank may have been damaged. Most of the rare plants are expected to recover within 1 to 3 years, although their populations may be reduced.

**200 Areas.** The annual review of the LLBGs was conducted in April of 2001 (Sackschewsky 2002). Due to access restrictions, visual observations from the burial ground perimeters were performed. The LLBGs include 218-E-10 and 218-E-12B in the 200 East Area, and 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 in the 200 West Area. The western half of 218-W-6, the undeveloped portion of 218-W-4C (along 16<sup>th</sup> Street), and the undeveloped portion of the 218-E-10 Burial Ground (north of the existing powerline) were not reviewed during recent evaluations.

Crouching milkvetch (*Astragalus succumbens*) and stalked-pod milkvetch (*Astragalus sclerocarpus*), State of Washington watch list species, were observed within the 218-W-4C Burial Ground and the extreme western edge of the 218-W-5 Burial Ground. Crouching milkvetch was also observed in the south end of the 218-W-6 Burial Ground. Piper's daisy (*Erigeron piperianus*), a State of Washington sensitive species was noted in the 218-E-12B and 218-E-10 Burial Grounds in previous years.

Birds observed within the 200 East Area LLBGs include long-billed curlews (*Numenius americanus*), killdeer (*Charadrius viociferus*), horned larks (*Eremophila alpestris*), Say's phoebe (*Sayornis saya*), American robin (*Turdus migratorius*), American kestrel (*Falco sparverius*), western meadowlark (*Sturnella neglecta*), and common raven (*Corvus corax*). Two bird species, loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*), Washington State candidate species, have been sighted in the vicinity of the 218-W-4C Burial Ground. Burrowing owls (*Athene cunicularia*), Washington State candidate species, have been observed in the vicinity of the 218-W-6 Burial Ground.

A 1998 amendment to the Fish and Conservation Act directs the FWS to identify species, subspecies, and populations of all migratory non-game birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (FWS 2002). These birds, designated as Birds of Conservation Concern, also include recently delisted species. Table 4.15 lists Birds of Conservation Concern, as recognized by the FWS, which have been observed on the Hanford Site.

**Table 4.14.** Washington State Plant Species of Concern Occurring on the Hanford Site, as Determined by the Washington Natural Heritage Program 2002 (Neitzel 2002a)

Common Name	Scientific Name	State Listing
annual paintbrush	<i>Castilleja exilis</i>	R1
awned halfchaff sedge	<i>Lipocarpa</i> (= <i>Hemicarpha</i> ) <i>aristulata</i>	R1
basalt milk-vetch	<i>Astragalus conjunctus</i> var. <i>rickardii</i>	R1
bristly combseed	<i>Pectocarya setosa</i>	W
brittle prickly pear	<i>Opuntia fragilis</i>	R1
Canadian St. John's wort	<i>Hypericum majus</i>	S
chaffweed	<i>Centunculus minimus</i>	R1
Columbia River mugwort	<i>Artemisia lindleyana</i>	W
coyote tobacco	<i>Nicotiana attenuata</i>	S
crouching milkvetch	<i>Astragalus succumbens</i>	W
desert dodder	<i>Cuscuta denticulata</i>	S
desert evening-primrose	<i>Oenothera caespitosa</i>	S
false pimpernel	<i>Lindernia dubia anagallidea</i>	R2
fuzzytongue penstemon	<i>Penstemon eriantherus whitedii</i>	R1
Geyer's milkvetch	<i>Astragalus geyeri</i>	S
grand redstem	<i>Ammannia robusta</i>	R1
gray cryptantha	<i>Cryptantha leucophaea</i>	S
Great Basin gilia	<i>Gilia leptomeria</i>	R1
hedge hog cactus	<i>Pediocactus simpsonii</i> var. <i>robustior</i>	R1
Kittitas larkspur	<i>Delphinium multiplex</i>	W
lowland toothcup	<i>Rotala ramosior</i>	R1
miner's candle	<i>Cryptantha scoparia</i>	R1
Piper's daisy	<i>Erigeron piperianus</i>	S
Robinson's onion	<i>Allium robinsonii</i>	W
rosy balsamroot	<i>Balsamorhiza rosea</i>	W
rosy pussypaws	<i>Calyptridium roseum</i>	S
scilla onion	<i>Allium scilloides</i>	W
shining flatsedge	<i>Cyperus bipartitus (rivularis)</i>	S
small-flowered evening-primrose	<i>Camissonia</i> (= <i>Oenothera</i> ) <i>minor</i>	R1
small-flowered nama	<i>Nama densum</i> var. <i>parviflorum</i>	R1
smooth cliffbrake	<i>Pellaea glabella simplex</i>	W
Snake River cryptantha	<i>Cryptantha spiculifera</i> (= <i>C. interrupta</i> )	S
southern mudwort	<i>Limosella acaulis</i>	W
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>	W
Suksdorf's monkey flower	<i>Mimulus suksdorfii</i>	S
winged combseed	<i>Pectocarya linearis</i>	R1
The following species have been reported as occurring on the Hanford Site, but the known collections are questionable in terms of location or identification, and have not been collected recently on the site.		
Beaked spike-rush	<i>Eleocharis rostellata</i>	S
dense sedge	<i>Carex densa</i>	S
few-flowered collinsia	<i>Collinsia sparsiflora</i> var. <i>bruciae</i>	S
giant helleborine	<i>Epipactis gigantea</i>	S
medic milkvetch	<i>Astragalus speirocarpus</i>	W
orange balsam	<i>Impatiens aurella</i>	R2
Palouse milkvetch	<i>Astragalus arrectus</i>	S
Palouse thistle	<i>Cirsium brevifolium</i>	W
porcupine sedge	<i>Carex hystericina</i>	S
Thompson's sandwort	<i>Arenaria franklinii thompsonii</i>	R2
S = Sensitive (i.e., taxa vulnerable or declining) and could become endangered or threatened without active management or removal of threats.		
R1 = Taxa for which there are insufficient data to support listing as threatened, endangered, or sensitive (formerly monitor group 1).		
R2 = Taxa with unresolved taxonomic questions (formerly monitor group 2).		
W = Taxa that are more abundant or less threatened than previously assumed (formerly monitor group 3).		

**Table 4.15.** Birds of Conservation Concern Observed on the Hanford Site (FWS 2002).

Common Name	Scientific Name
Swainson's hawk	<i>Buteo swainsoni</i>
ferruginous hawk	<i>Buteo regalis</i>
golden eagle	<i>Aquila chrysaetos</i>
peregrine falcon	<i>Falco peregrinus</i>
prairie falcon	<i>Falco mexicanus</i>
grasshopper sparrow	<i>Ammodramus savannarum</i>
greater sage grouse (a)	<i>Centrocercus urophasianus phaios</i>
American avocet	<i>Recurvirostra americana</i>
solitary sandpiper	<i>Tringa solitaria</i>
long-billed curlew	<i>Numenius americanus</i>
marbled godwit	<i>Limosa fedoa</i>
sanderling	<i>Calidris alba</i>
Wilson's phalarope	<i>Phalaropus tricolor</i>
flamulated owl	<i>Otus flammeolus</i>
burrowing owl	<i>Athene cunicularia</i>
Lewis' woodpecker	<i>Melanerpes lewis</i>
loggerhead shrike	<i>Lanius ludovicianus</i>
Brewer's sparrow	<i>Spizella breweri</i>
sage sparrow	<i>Amphispiza belli</i>
sage thrasher	<i>Oreoscopets montanus</i>
(a) Endangered Species Act candidate.	

#### 4.6.5 Microbiotic Crusts

Microbiotic crusts generally occur in the top 1 to 4 mm (0.04 to 0.16 in.) of soil and are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. Microbiotic crusts are common in the semiarid Columbia Basin, where the dominant form tends to be green algae (Johansen et al. 1993). The functions of microbiotic crusts include soil stability and protection from erosion, fixation of atmospheric nitrogen, nutrient contribution to plants, influencing soil-plant water relations, increasing water infiltration, seedling germination, and plant growth. The ecological roles of microbiotic crusts depend on the relative cover of various crustal components. Carbon inputs are higher when mosses and lichens are present than when the crust is dominated by cyanobacteria. Nitrogen inputs are higher with greater water infiltration. Soil surface stability is related to cyanobacterial biomass as well as total moss and lichen cover (Belnap et al. 2001). The lichen and mosses of the Hanford Site were surveyed and evaluated by Link et al. (2000). They found 29 soil lichens in 19 genera and 6 moss species in 4 genera. Twelve (41 percent) lichen species are of the crustose growth form (flat and firmly attached to the substrate), eight (28 percent) are squamulose (having small, flat scales that do

not adhere tightly to substrate), seven (24 percent) are foliose (having leaf-like lobes, attached in the center to substrate by clusters of rhizomes) and two (7 percent) are fruticose (plant-like growth attached at one point).

#### **4.6.6 Biodiversity**

The Hanford Site is located within the Columbia Basin Ecoregion, an area that historically included over 6 million ha (14.8 million ac) of steppe and shrub-steppe vegetation across most of central and southeastern Washington state, as well as portions of north-central Oregon. The pre-settlement vegetation consisted primarily of shrubs, perennial bunchgrasses, and a variety of forbs. An estimated 60 percent of shrub-steppe in Washington has been converted to agriculture or other uses. Much of what remains is in small parcels, in shallow rocky soils, or has been degraded by historic land uses (mostly livestock grazing) (TNC 1999).

The Hanford Site retains some of the largest remaining blocks of relatively undisturbed shrub-steppe in the Columbia Basin Ecoregion. Hanford's importance as a refuge for the shrub-steppe ecosystem is not solely size-related, however. The presence of a high diversity of physical features and examples of rare, undeveloped deep and sandy soil has led to a corresponding diversity of plant and animal communities. Many places on the Hanford Site are relatively free of non-native species and are extensive enough to retain characteristic populations of shrub-steppe plants and animals that are absent or scarce in other areas. Because of its location, the site provides important connectivity with other undeveloped portions of the ecoregion.

### **4.7 Cultural, Archaeological, and Historical Resources**

The Hanford vicinity is one of the most culturally rich resource areas in the western Columbia Plateau. The site consists of a series of cultural landscapes containing the cumulative record of multiple occupations by Native and non-Native Americans. These landscapes contain numerous well-preserved archaeological sites representing prehistoric, ethnographic, and historic periods. Period resources include sites with cultural materials that are thousands of years old, traditional cultural places, and buildings and structures from the pre-Hanford, Manhattan Project, and Cold War eras. The National Historic Preservation Act (16 USC 470), the Native American Graves Protection and Repatriation Act (25 USC 3001 et seq.), the Archaeological Resources Protection Act (16 USC 469 et seq.), and the DOE American Indian Policy (DOE 2000), among other legislation and guidelines, require the identification and protection of areas and resources of concern to the Native American community (see Sections 6.13 and 6.14).

#### **4.7.1 Native American Cultural Resources and Archaeological Resources**

Traditional Native American religion is manifest in the earth, the water, the sky, and all animate or inanimate beings that inhabit a given location. In prehistoric and early historic times, Native Americans of various tribal affiliations populated the Hanford Reach of the Columbia River. The Wanapum and the Chamnapum dwelt along the Columbia River from south of Richland upstream to Vantage (Relander 1956; Spier 1936). Some of their descendants (Wanapum) still live nearby at Priest Rapids;